

1. A fuel processor comprised of a hydrogen generating apparatus, a single vessel heat-integrated multi-stage water-gas shift reactor, a multifunctional heat exchanger, a multiple heat source boiler, and a single vessel water heat exchanged multi-staged preferential oxidation reactor, that provides hydrogen to a fuel cell stack and that is integrated by more than one means with said fuel cell stack.
2. The fuel processor according to claim 1 wherein said hydrogen generating apparatus is comprised of a combustion chamber, a burner, a steam reformer catalytic reactor, and a heat exchanger.
3. The hydrogen generating apparatus according to claim 2 wherein said combustion chamber has sufficient volume to provide a residence time, that is for the combustion products at normal temperature and pressure in the range of 1 second to 15 seconds, preferably 2 seconds to 10 seconds.
4. The hydrogen generating apparatus according to claim 2 wherein said combustion chamber is cylindrical with a length to diameter ratio in the range of 0.5 to 4.0, preferably from 1.0 to 3.0.
5. The hydrogen generating apparatus according to claim 2 wherein said combustion chamber has a burner mounted on the sidewall of said combustion chamber.
6. The combustion chamber according to claim 5 wherein said burner is a metal fiber burner operating in a high-intensity blue flame mode releasing the major part of the energy in a convective way.
7. The metal fiber burner according to claim 6 wherein said burner is a knitted metal fiber burner.
8. The knitted metal fiber burner according to claim 7 wherein said burner operates at temperatures up to 1920°F.
9. The knitted metal fiber burner according to claim 7 wherein said burner has a heating intensity from 900 kW/m² to 5000 kW/m² and preferably from 1000 kW/m² to 3000 kW/m².
10. The knitted metal fiber burner according to claim 7 wherein the metal fibers of said burner are manufactured from a FeCr alloy steel containing the following elements, iron, chromium, aluminum, yttrium, silicon, manganese, copper, and carbon.
11. The knitted metal fiber burner according to claim 7 wherein said burner operates simultaneously with more than one fuel.
12. The knitted metal fiber burner according to claim 11 wherein one of said fuels is a hydrocarbon and the other is a mixture of gases containing carbon dioxide and hydrogen.
13. The mixture of gases containing carbon dioxide and hydrogen according to claim 11 wherein said mixture is obtained by a means of integrating the fuel processor with a fuel cell stack and said mixture is the anode off-gas from said fuel cell stack.
14. The fuels according to claim 11 wherein the hydrocarbon is one of the following, liquefied petroleum gas, natural gas, or diesel fuel and the mixture is the anode off-gas from a fuel cell stack whose proportions of carbon dioxide, hydrogen, and other gases vary with the operating conditions of said fuel cell stack.
15. The combustion chamber according to claim 5 wherein said burner is comprised of a ceramic material.
16. The ceramic burner according to claim 11 wherein said burner operates at temperatures up to 2100°F.

17. The steam reformer according to claim 2 wherein the steam reforming catalyst is located within a U-shaped reaction vessel located inside combustion chamber according to claim 5.
18. The heat exchanger according to claim 2 wherein said heat exchanger is a double pipe heat exchanger transferring heat from the combustion chamber flue gas leaving the combustion chamber to the mixture of reactant gases being fed to a fixed bed of steam reforming catalyst, said heat exchanger being located at the top of the combustion chamber.
19. The fuel processor according to claim 1 wherein said single vessel heat integrated multi-staged water-gas shift reactor is comprised of two or more water-gas shift reactors, and a means of exchanging heat with a multi-functional heat exchanger.
20. The single vessel heat integrated multi-staged water-gas shift reactor according to claim 19 wherein at least one of the water-gas shift reactors within a single vessel is operated at a greater temperature and at least one other within the same vessel is operated at a lesser temperature.
21. The single vessel heat integrated multi-staged water-gas shift reactor according to claim 19 wherein the gas mixture leaving the water-gas shift reactor that is operated at the greater temperature is cooled by passing through a multi-functional heat exchanger prior to entering the water-gas shift reactor that is operated at the lesser temperature, during normal operating conditions.
22. The single vessel heat integrated multi-staged water-gas shift reactor according to claim 19 wherein the gas mixture leaving the water-gas shift reactor that is operated at the greater temperature is heated by multi-functional heat exchanger prior to entering the water-gas shift reactor that is operated at the lesser temperature, during start-up conditions while the water-gas shift reactor that is operated at the lesser temperature has a temperature less than the temperature of the multiple heat source boiler of claim 1.
23. The fuel processor according to claim 1 wherein said multi-functional heat exchanger is comprised of means of receiving and providing heat to a water-gas shift catalyst bed operated at a greater temperature, a water-gas shift catalyst bed operated at a lower temperature, a multiple heat source boiler, and a means of receiving heat from an electrical device.
24. The multi-functional heat exchanger of claim 23 wherein said heat exchanger receives heat from a process gas mixture exiting a water-gas shift reactor operating a greater temperature returning said gas mixture at a lower temperature to a water-gas shift reactor operating at a lower temperature and transfers said heat to water arriving from the multiple heat source boiler of claim 1 and returning said water in the form of a water-vapor mixture to said multiple heat source boiler, during normal operation.
25. The multi-functional heat exchanger of claim 23 wherein said electrical device is an immersion water heater physically located with said multi-functional heat exchanger.
26. The multi-functional heat exchanger of claim 23 wherein said heat exchanger transfers heat generated by said electrical device to water arriving from the multiple heat source boiler of claim 1 and returning said water in the form of a water-vapor mixture to said boiler, during the initial start-up of said boiler, when the water temperature of said multiple heat source boiler is less than its boiling point.
27. The multi-functional heat exchanger of claim 23 wherein said heat exchanger transfers heat generated by said electrical device to the process gas mixture of claim 24